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GLACIATION OF NORTHWESTERN HOLMES COUNTY, OHIO.*

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CONTENTS.

INTRODUCTION AND ACKNOWLEDGMENTS.

In a part of Ohio the Wisconsin ice sheet advanced into a region of considerable relief, up to and just over the main preglacial divide. The effects of glaciation on a region of deep valleys, the character of the glacial boundary, and the deposits—especially the kames and kame terraces in the valleys—will be described in detail. The geology—stratigraphic, economic, and glacial—of all of Holmes County has been studied, but this paper is concerned with the glaciation of the northwestern part, because the glacial phenomena of a hilly region are well developed here. Northwestern Holmes County is bounded on the north by Ashland and Wayne counties and on the west by Ashland County. This area lies in Washington, Ripley, and portions of Knox and Monroe townships, and is shown on the Loudonville quadrangle of the United States Geological Survey. The areal map accompanying is drawn on a portion of that sheet.

*Published with permission of the Director, Geological Survey of Ohio.

To Mr. Wilber Stout, Director of the Geological Survey of Ohio, I am deeply indebted for co-operation and helpfulness at all stages of the investigation of the geology of Holmes County, and I take this means of expressing my sincere thanks and appreciation. My wife has helped in the preparation of the manuscript for which I am grateful.

FIG. 1. Index Map.

DRAINAGE.

Except for a small southern portion of this area which is drained by small streams directly tributary to the Mohican River or tributary to Black Creek, several miles south of the glacial boundary, most of the area is drained by Lake Fork of the Mohican River and its tributaries. Lake Fork, formed by the junction of Jerome Fork and Muddy Fork in Mohican Township, Ashland County, flows in a general southerly

direction through Lake Township, Ashland County and Washington Township, Holmes County and joins the Mohican River in the south part of the area near the Washington-Knox township line. The stream's present course is post-glacial. The preglacial drainage was by a large stream flowing east in a wide valley which has been traced from Wooster to Shreve, thence across northern Washington Township, Holmes County, to Loudonville, and on to the northwest.* This abandoned valley is spoken of by Leverett† as the "old Mohican" and will be referred to as the *preglacial Mohican* in the present report.

The valley of the present Lake Fork is made up of two parts. The first is that of a preglacial stream which rose in Mohican Township, Ashland County, and joined the valley of the preglacial Mohican at the Ashland-Holmes county line.‡ The other, and lower portion of the present valley was formerly occupied by a small stream flowing north from the southwestern part of Washington Township, Holmes County, to the valley of the preglacial Mohican in Section 33 of the same township. It is possible that this preglacial stream swung to the northeast in central Section 4 and entered the large valley in Section 34. A wide depression, partially drift filled is present here. This depression was the course of escape of considerable melt water from the ice.

With the coming of the glacier, the preglacial Mohican was dammed, the waters extended up the tributary valleys to the south, and escaped over low places in the divides, thus forming the present Lake Fork and Black Fork. It is possible that this diversion of the drainage took place in pre-Wisconsin time. Because of the narrowness of the valleys, it is thought that the formation of the present Black Fork and Lake Fork of the Mohican River did not take place earlier than Illinoian time.§ Other and smaller streams were also deranged by glaciation. Sigafoos Run, which formerly flowed north from northern Knox Township and entered Lake Fork (reversed) in Section 4 of Washington Township, was a larger stream than preglacial Lake Fork south of the preglacial Mohican. Sigafoos Run, where it leaves its old valley, flows directly west across a low place in the hills and enters the Mohican River just below the mouth of Lake Fork. This postglacial portion, about a mile in length, is a deep narrow gorge just at the glacial boundary.

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*Todd, J. H., Preglacial Drainage of Wayne and Adjacent Counties: Ohio Academy of Science, Special Papers, No. 3, pp. 46–67, 1900.
Ver Steeg, Karl, Drainage Changes in the Vicinity of Wooster, Ohio: Ohio Jour. of Science, Vol. 30, pp. 309–314, 1930.

†Leverett, Frank, Glacial Formations and Drainage Features of the Erie and Ohio Basins: Mon. 41, U. S. Geol. Survey, p. 164, 1902.

‡Hubbard, G. D., Stream Diversion near Lakeville, Ohio: Ohio Naturalist, Vol. 7, pp. 349–355, 1908.

§Killbuck Creek, which flows south through a wide valley in the central part of Holmes County, is believed to have been forced into its present course by some ice sheet earlier than Illinoian. The features of this valley will be discussed elsewhere.

RELIEF AND ITS EFFECT ON GLACIATION.

The main reason for the difference between the deposits in this portion of Ohio and those in other parts of the state is the relief of the region into which the ice sheet advanced. The country immediately to the north of the glacial boundary could not have been markedly different from that to the south.

The region in general is a plateau in early maturity. Flat areas, remnants of the Harrisburg peneplain,* remained on the divides at an elevation of approximately 1,220–1,240 feet. In northeastern Knox, southwestern Ripley, and northwestern Monroe townships the ridges, along the main preglacial divide mentioned by Coffey,† are about 100 feet higher, with monadnocks above the general level reaching to almost 1,400 feet. The elevation of the rock floor of the preglacial Mohican varies from 835 feet at Loudonville to 801 feet at Lakeville.‡ The present altitude of the abandoned valley, now partially filled with drift, is from 920 to 1,000 feet.

Glacial features dependent on the ice advance into such a terrain have been studied in Holmes County, and the area described shows these at their best development. They have been seen by the writer in Knox, Ashland, Wayne, and Richland counties, and probably are to be found to some extent in the other hilly portions of Ohio into which the ice advanced. It is hoped that further detailed work in the hilly regions east and west of Holmes County will extend our knowledge of this type of deposit.

Because of the relief of the region, several factors affected the work of the last ice-sheet near the glacial boundary:

1. Difficulty of ice advance.
2. Reversal of streams in valleys already formed, but no (or little) cutting of new valleys, except across divides to enter another valley.
3. Preservation of the major features of the preglacial topography.
4. Uneven melting and retreat of the ice front, with little forward motion during retreat and with many blocks and masses of ice left behind.

1. Obviously, if the glacier had to advance over an uneven and rugged surface, the rate of advance would be less than if it had a fairly level surface over which to move. Probably this accounts for the fact that none of the continental glaciers advanced as far in eastern Ohio as they did in the central and western part of the state.

2. If the glacier advanced over a reasonably level surface, the major valleys would probably be filled with drift, and upon melting of the ice, the streams would be forced to make new valleys and channels for themselves, which would seldom coincide with previous stream courses. On the other hand, if the glacier advanced over a region of

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*Stout, Wilbur, and Lamborn, R. E., Columbiana County: Geol. Survey of Ohio, Bull. 28, p. 38, 1924.

†Coffey, G. N., Preglacial, Interglacial and Postglacial Changes of Drainage in Northeastern Ohio with Special Reference to the Upper Muskingum Drainage Basin: Ohio Jour. Science, Vol. 30, map p. 375, and p. 377, 1930.

‡Todd, J. H., Preglacial Drainage of Wayne and Adjacent Counties: Ohio Acad. Sci., Special Papers, No. 3, pp. 46–67, 1900.

marked relief, such as the one under discussion, and did not fill the valleys with drift, the streams on their reappearance after (and during) the melting of the ice, would find it easier to flow in valleys already present. The direction might be reversed and cols from one drainage system to another might be cut through low divides, but in large part the valleys would be preglacial.

3. The preservation of the major features of the preglacial topography in northwestern Holmes County and in other hilly portions of Ohio near the glacial boundary is due not only to the relief of the land over which the glacier advanced, but also to the fact that the advancing glacier was nearing its farthest extent and was hence undoubtedly thinner and much more sluggish than in its advance over the territory to the north. Although the territory to the north may have had less relief originally, the glacier being more active there was able to subdue the topography to a far greater degree than it was that farther to the south.

As detailed descriptions, which will be given later, show, the lowland is more or less covered with thick drift deposits. The high land, on the other hand, is in most places covered with a sheet of till, which is described as gound moraine. As a general rule, the higher the ridge the thinner the till. On some of the hilltops the till is thin or absent and the bedrock is exposed. The small amount of glacial erosion or deposition on the uplands is shown by the fact that the Harrisburg peneplain remnants are concordant on both sides of the glacial boundary. The gross form of the hills is preglacial.

The preglacial valleys are a dominant factor of the present topography. Some now carry streams; some do not. Not only are the major valleys of preglacial times still evident, but many of the smaller valleys seem to be of preglacial origin.

4. The glacial deposits in the valleys are the most noteworthy features in this area. These valley deposits are not of the usual valley train type which have been dissected by later stream erosion. They are deposits laid down by melt water around, between, and over blocks and masses of ice left behind in the valleys after the main ice front had melted back to the north. In some cases the stratified deposits were laid down in temporary lakes, but in most they seem to have been deposited by running water. Stagnation of the ice sheet, as postulated by Flint* in Connecticut, is not thought to have occurred in a very large part of Ohio. Near the glacial boundary, however, and in fact in this whole area, once the ice had advanced to its farthest extent, very little forward motion as the ice melted away, was present. The glacier near the ice front melted away in a ragged fashion leaving behind blocks and masses of ice where it had originally been thicker, namely, in the valleys. When the ice had advanced to its farthest extent, the ice front and that part of the ice directly back of the ice front, must have been thin on top of the ridges, as shown by the little erosion and small

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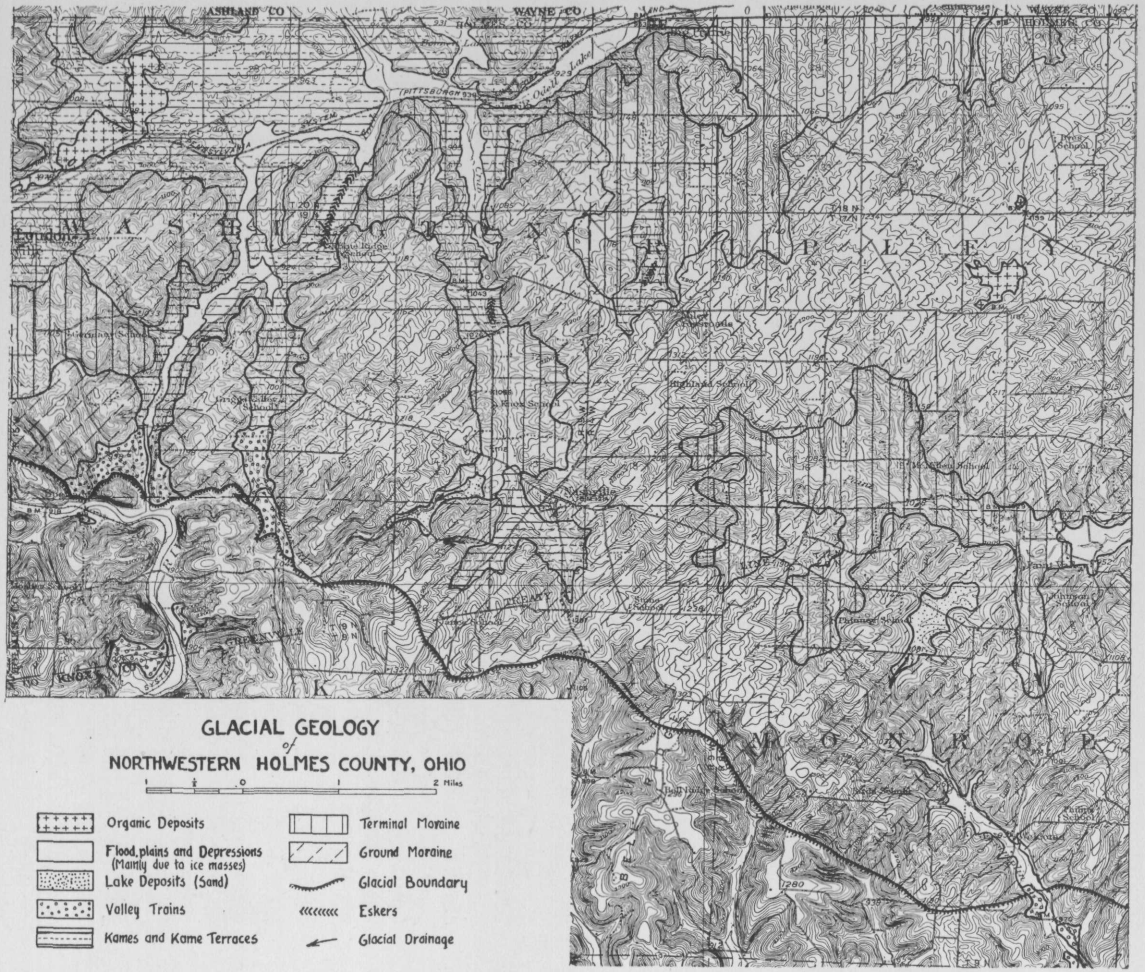
*Flint, R. F., The Stagnation and Dissipation of the Last Ice Sheet: Geogr. Rev., Vol. 19, pp. 265–289, 1929.

Flint, R. F., Glacial Geology of Conn: Conn. State Geol. and Nat. Hist. Survey, Bull. 47, 1930.


GLACIAL GEOLOGY
of
NORTHWESTERN HOLMES COUNTY, OHIO
1 ½ 0 1 2 Miles
Organic Deposits
Flood plains and Depressions (Mainly due to ice masses)
Lake Deposits (Sand)
Valley Trains
Kames and Kame Terraces
Terminal Moraine
Ground Moraine
Glacial Boundary
Eskers
Glacial Drainage
ASHLAND CO
WAYNE CO
HOLMES CO
W A S H I N G T O N
R I P L E Y
K N O X
M O N R O E
Nashville
Odell Lake

amount of deposition there. The present valleys are from 200–300 feet deep, and if the thickness of the valley filling is added, they were from 100–200 feet deeper when the ice advanced into the area. Therefore, it is believed that when the ice melted away, it melted from the hilltops first, exposing the hills and ridges while ice still remained in the valleys, and that across this area there was no definite ice front at any time during the melting away of the glacier. The deposits in the valleys are such as would be deposited from and around these detached masses of ice remaining.

GLACIAL BOUNDARY.

The Wisconsin glacier advanced into Holmes County, reaching the top, and pushing slightly over the top of the main divide that runs in a general east-west direction across the county. This preglacial divide and the higher land near it was one of the factors which allowed the ice sheet to go no farther. From east to west the drift border runs one-half mile south of the village of Winesburg, southwest to just south of Berlin, crossing the valley of Doughty Creek at Wise School two miles south of Berlin, thence in a winding manner to Killbuck Creek at the junction of Sand Run with that stream one and one-half miles south of Millersburg. From Killbuck Creek the boundary is due west across western Hardy Township and eastern Monroe Township, crossing the valley of Shrimplin Creek three-fourths of a mile south of the hamlet of Welcome. One mile west of Shrimplin Creek it turns to the northwest across southwestern Monroe Township, crossing Bell Ridge three-fourths of a mile north of Bell Ridge School, passing just south of the top of the 1,400 foot knob two miles south of Nashville, and extending in an undulating fashion to Sigafoos Run in southwestern Section 22 in Knox Township. From here it follows Sigafoos Run to the junction of that stream with the Mohican River and thence in a westerly direction across the southern edge of Washington Township to the Holmes-Ashland county line. It passes about two miles south of Loudonville, just south of the Turkey Ridge School in Hanover Township, Ashland County.

Along the glacial boundary in Monroe, Knox, and Washington townships, topography and deposits, which are definitely of terminal morainic character, do not approach closer than two miles to the boundary except in the valleys, and at one place near Loudonville. The statement by Leverett* that "drift knolls with their fresh topography continue right up to the glacial boundary" and of Wright† that the boundary "line is very sharply defined", is true only in some of the valleys, especially those of Killbuck and Doughty creeks, in the central and western part of Holmes County.

Thick drift deposits are not found on the hilltops and ridges within a half mile, and in some cases a mile, of the boundary. Approaching

*Leverett, Frank, Glacial Formations and Drainage Features of the Erie and Ohio Basins: Mon. 41, U. S. Geol. Survey, p. 390, 1902.

†Wright, G. F., The Glacial Boundary in Western Pennsylvania, Ohio, Kentucky, Indiana, and Illinois: Bull. 58, U. S. Geol. Survey, p. 60, 1890.

the boundary from the north in marking it out on the map, one passes from thick drift to thin drift, thence to discontinuous drift on this preglacial divide, and then into a region where the bedrock is at the surface and one finds only a few scattered foreign boulders. The farthest southerly extent of these scattered boulders has been taken as the limit of the Wisconsin ice advance. The deposits within a mile or more of the glacial boundary cannot be spoken of as a terminal moraine. Furthermore, those so called terminal morainic deposits closest to the glacial boundary are, as will be explained later, associated with low places in the surface and are not due to their proximity to the limit of glaciation. Valley deposits, such as the one in Lake Fork valley, are not morainic, although they have a knob and kettle topography, but are kame-like deposits. South and southeast of Loudonville along the Ashland-Holmes county line, morainic topography and deposits are found on the upland, the only place in the area where such is the case. Even here a belt almost a mile wide, in which the drift is thin and not morainic in expression, is found between the definite moraine and the glacial boundary.

The character of the marginal deposits is well shown along Bell Ridge which runs north and south in eastern Knox Township a little less than a mile west of Monroe Township. At Stones School, one and one-half miles south of Nashville, the drift is thick and bedrock is not visible. As one goes south from Stones School the drift continues thick for about a half mile. From this point onward the drift becomes notably thinner until about a mile south of Stones School it seems to end. However, as one progresses along the road and through the fields an occasional igneous boulder from one to two feet in diameter may be seen for about three-eighths mile to the south. The thickness of the drift south of Stones School is well shown where the Middle Kittanning coal is being stripped from the top of the ridge on the Wallace Bell farm. The overburden taken out by the steam shovel shows the material to be residual and not glacial soil. The boulders, never very abundant, become fewer and fewer until, a little more than a mile south of Stones School, no more boulders were observed beyond a line three-fourths of a mile north of Bell Ridge School. The glacial boundary was mapped at these last foreign boulders which were seen along the ridge top.

The same situation is found along the north-south ridge in western Monroe Township about a mile east of the Knox Township line.

One of the points of easiest accessibility, where the transition may be seen of the thick drift to the thin drift, of the thin drift to the discontinuous phase, and hence to the scattered boulder phase at the glacial boundary, is along the gravel road running south from Loudonville toward Spellacy, in Section 12 and Section 13 of Hanover Township, Ashland County. As one climbs onto the upland south of the Loudonville corporation limit, one crosses a morainic area which will be described later. The drift here is quite thick. At the line between Section 12 and Section 13 of Hanover Township the morainic area gives way on the south to a ground moraine area which is much flatter and less hummocky than the morainic area to the north. A quarter of a mile

south of this section line the drift is thin. The bedrock can be seen in the road ditch overlain by from two to four feet of till. One-half mile south of the section line the drift is so thin that the bedrock appears at the surface and no more till is seen. For about three-eighths of a mile, however, along the ridge traversed by this road, an occasional foreign boulder is present. Where the road crosses the county line the last foreign boulders were observed.

Two factors may be responsible for the thin edge of the drift deposit in this area. *First*, the ice front as it advanced up to and just over this main divide was undoubtedly quite thin and was not capable of carrying very much material. Apparently at its farthest extent the ice edge did not remain stationary for any length of time; rather it seemed to advance to the point of farthest extent and immediately draw back. Under such circumstances it is quite likely that little in the way of deposit could be made. On the northerly slopes of this main east-west divide the ice edge remained for a longer time and consequently the drift is thicker.

Second, this main divide of which these north-south ridges are spurs, is dissected deeply by southward flowing streams. In the valleys of these southward flowing streams little or no drift can be seen. The southerly slope of this divide may have been cut into by post-glacial erosion of the southward flowing streams working back to the north by headward erosion. In such a case any deposits would be removed from the valleys and the only remnants would be on the divide and ridges. Where the ridges are not very flat-topped, the material might creep and slide into the valleys and be removed by erosion. This factor is not thought to have been nearly so important as the first mentioned.

It might be noted in this connection, that the valleys of southward flowing streams in western Monroe and Knox townships, which head at the glacial boundary or beyond, (Shrimplin Creek excepted) contain little or no outwash material. Extended search of these valleys was made, and beyond an occasional granite pebble, no material, which could be identified as glacial outwash, was found. Probably these valleys originally had very little outwash material and postglacial erosion has removed that little.

It may be noted in this place that the Illinoian glacial boundary, which is supposed to extend south from a point one and one-half miles south of Nashville to the Walhonding River,* was not found. Indeed, in western Knox and Richland townships of Holmes County, supposed to have been covered by the Illinoian ice, no indication of glacial deposit of any age was seen. Neither was such indication seen in northeastern Jefferson Township, Knox County, nor in southeastern Hanover Township, Ashland County.

DEPOSITS.

The deposits left by the ice may be divided into two groups: till, or unstratified drift, and stratified drift. Till was deposited directly

*Leverett, Frank, Mon. 41, U. S. Geol. Survey, p. 225, 1902.

by the ice as it advanced over the region, or was dropped when the ice retreated. The stratified deposits were laid down by water flowing from the melting ice, depositing material in glacial streams or lakes.

Unstratified Drift.

The unstratified or till deposits are of two kinds: ground moraine and terminal moraine. The distinction is based on surface expression. The ground moraine is only slightly undulating, and is said to have a "weak" expression, whereas the terminal moraine has a "stronger" surface expression.

The Ground Moraine.

The upland surfaces and higher hill slopes are covered with boulder clay or till which is called the ground moraine. The average thickness of the till in this area is hard to arrive at because on some of the hilltops, especially near the glacial boundary, the till is absent and in other places, several miles to the north of the glacial boundary, especially over most of Ripley Township, the till may be 50 feet or more in thickness. The average thickness of the till in Wayne County to the north and northeast is 20 feet.*

The material making up the till was carried by the glacier from the north and deposited, both as the glacier advanced, when the material was sloughed off the heavily loaded lower part of the ice, and when the ice melted away. It was deposited with little or no sorting by running water from the melting ice. The ground moraine is divisible at some outcrops into two parts: a lower, more clay-like, compacted part; and an upper, more gravelly, loose part. These were called long ago by Upham† the "lower till" and the "upper till." The lower till, which is the thicker, is believed to have been deposited as the ice advanced and hence was packed down by the weight of the ice over it. The upper till was thought to have been deposited as the ice melted back and some water sorting is evident at places. This division of the ground moraine into an upper till and a lower till is better shown in the glaciated parts of central and eastern Holmes County and will be described more fully elsewhere.

The till is a sandy or silty clay, with many fragments of rock which are subangular and sometimes rounded. The size of these fragments varies from silt and sand grains to pebbles and boulders which may be 4 feet or more in diameter. The material of the till is largely of local derivation. It was derived mainly from shaly Waverly (Mississippian) sandstone which is the bedrock of most of the region‡ and of that to the north over which the glacier advanced to reach this position. Mixed in with the silt and Waverly sandstone fragments are pebbles, cobbles, and boulders of igneous and metamorphic rocks which were carried

*Conrey, G. W., Wayne County: Geol. Survey of Ohio, Bull. 24, p. 32, 1921.

†Upham, Warren, Chapter in Hitchcock, C. H., Geology of New Hampshire: Vol. 3, pp. 285–287, 1878.

‡Some lower Pennsylvanian layers are found on the higher hilltops. These are mainly sandstone. Near Nashville the rocks are as young as Allegheny.

down from the north of Lake Erie. These foreign boulders and cobbles do not make up nearly so large a proportion of the whole as they appear to do when an outcrop is first seen. When any given till bank is examined closely the percentage of foreign material is seen to be small. Most of this till, therefore, was carried but a short distance—but a few miles—and most of it is believed to have been carried less than 25 miles.

Near the top the till is buff or yellow in color. Where fresh exposures are seen, the lower part is usually bluish-gray. This is due to the unoxidized character of that more deeply buried. Both the yellow and the blue till are believed to have the same origin, the yellow having been oxidized, the blue not as yet oxidized. The depth of oxidation is variable, depending on permeability of the till, and slope of the land. Clear exposures, where slumping has not yet had a chance to occur, are rare and a definite average for the depth of oxidation of the till is not attempted.

The till is believed to cover the entire surface, but in the valleys it is concealed by later stratified deposits. The thickness of the ground moraine in the valleys is not known. How much of the valley filling is made up of gravel deposits, and how much is underlying till, is undetermined. Well records are not kept in sufficient detail so that the filling can be differentiated into gravel and till.

The topography of the ground moraine is somewhat variable. In general, the deposits were plastered on ridge tops or ridge sides. In many places the surface is smooth (not necessarily level) and does not undulate, so that very little suspicion of glaciation would be created in anyone's mind examining this area of weak expression for the first time. At other places, the ground moraine is somewhat billowy and grades with some intermediate stages into a hummocky topography, having a stronger expression, which is mapped as being topography of terminal morainic type. This will be treated under a separate heading below.

In northwestern Monroe Township the topography of the ground moraine is only slightly undulating, the undulating character increasing to the north in the valleys. In the valley of Paint Creek hillocks of drift cause a morainic topography.

In southern Ripley Township north of Paint Valley, in the region of Hopewell Church, the uplands are very heavily drift covered. Practically no bedrock is visible in this township. The till is quite thick; 25 feet or more may be seen in many places. The uplands here are gently undulating, but only a slight suspicion of sag and swell topography is present. Here the till is sandy in the upper part with the lower part more clay-like. The drift is only moderately stony with few stones over 6 inches in diameter. An occasional boulder up to 3 or 4 feet may be seen in the fields. This is the territory in which some of the finest farming land of Holmes County is found. This character of the drift is more or less continuous from Hopewell Church west as far as Miley Crossroads in central western Ripley Township. Here, however, the surface of the drift is more undulating and the boundary is hard to draw between the undulating ground moraine and the hummocky,

definitely terminal morainic area associated with the lowlands of the preglacial Mohican valley.

In eastern Washington Township in sections 1 and 36 the drift covering the hilltop is slightly undulating, but is known to be not very thick because bedrock shows in a few places. The uplands between Griggs Valley and the valley of Crab Run in sections 10, 11, 14, and 15 of Washington Township are quite thickly covered with till. Very few exposures of the bedrock are to be seen. The till veneer conforms to the surface of the preglacial hills. On the more or less flat upland a little undulation is present and the surface is slightly billowy on either side of the state road in sections 14 and 15. The ridge between the valley of Lake Fork and Griggs Valley in sections 16, 17, and 9 in the southern part of Washington Township is thickly covered with till on the northern end, but on the southern end, which is bounded by postglacial Sigafoos Run, the till is very thin and discontinuous. The character of the ground moraine south of the area of terminal moraine near the county line north of Spellacy has been described in connection with the glacial boundary.

The high hills in the northwestern corner of Washington Township and across the county line in Green and Lake townships of Ashland County are covered with till which seems to conform with the shape of the preglacial hillsides. The thickness and surface expression of the till in the parts of Green and Lake townships, Ashland County, which border on Holmes County, are of the same character as in Washington Township, Holmes County.

Except for the northeastern corner, Knox Township was invaded to only a small extent by the glacier. The drift covering is of the glacial boundary type rather than that of the hills farther to the north which were more heavily overridden by the ice. In the area north of Stones School in the northeastern corner of Knox Township, the drift is quite thick, obscuring the bedrock, and the topography is somewhat suggestive of a sag and swell type. South of the gravel area just south of Nashville, south of Stones School, and south of that portion of Sigafoos Run to the north of the glacial boundary, the till is quite thin and the bedrock is often visible. This region lies on top and to the south of the top of the main divide running across the area. Apparently the ice was just barely able to overtop this ridge. While the till is very thin here, the number of large igneous boulders, many of them 3 to 5 feet in diameter, lying on the surface, is greater than is usual any place else in the region.

The Terminal Moraine.

Areas having a "terminal morainic" topography are shown on the map. These areas do not seem to mark any definite ice edge where the ice front halted, making a thicker drift deposit, but rather they seem to be connected with low places of the region, and are mapped to show a definite type of surface. These discontinuous areas of terminal moraine could be connected from valley to valley, and a very respectable

series of loops produced. Conrey* found comparable conditions in southern Wayne County to the north:

> ". . . . drift accumulations of a morainic character extend across the southern townships in a discontinuous belt, being well developed in the valleys and of minor importance on the uplands. . . . . If these areas are connected across the intervening uplands they will correspond to the middle and inner or northern belts described by Leverett. The distribution of morainic accumulations in this region near the glacial border apparently has been determined to no small extent by the large preglacial valleys which are at places filled with drift knolls and ridges, while the uplands nearby show comparatively few morainic features. Especially is this true of the east-west valleys, that is, in those at right angles to the direction of the movement of the ice."

The material of the terminal morainic areas is much like that of the ground moraine, the major difference is in the "stronger" surface expression and not in the character of the material. As described under the ground moraine this till is composed of pebbles contained in a silty, clay-like matrix. Occasional areas of gravel deposits are found, but they are usually small and at the upper surface of the till.

Areas such as this, with a knob and kettle topography made up of hap-hazardly placed drift knolls, with depressions between, are usually interpreted as having been caused by the standing or the oscillation of the ice front over a narrow belt at the line of farthest ice advance, or later at some stage of the glacial retreat. The area south of Loudonville may have been formed in this way. The other areas, however, are definitely related to valleys rather than to any standing of the ice edge. The following explanation is offered for the deposition of these masses of unevenly surfaced till. The glacier advanced over the region, but it is supposed that the ice was not very thick, especially at the edge. The thickness of the ice over, and in the valleys would naturally be greater than that on the hilltops. As the ice advanced, considerably more material would be sloughed and scraped off the bottom of the ice in the valleys than on the hilltops. In fact, on the hilltops erosion rather than deposition by the advancing ice may have been the major feature. In the valleys more opportunity for ice blocks to accumulate in the drift would also be afforded. After the glacier had reached its line of greatest advance, it would melt away and down on the hilltops as well as back, so that the hilltops appeared above the surface of the glacier while the valleys were still filled with ice. The drift was already thicker in the valleys, for as the ice was thin on the hilltops, there could be less material contained in the ice here than in that in the valleys. Ice remaining in the valleys would take much longer to melt, would melt unevenly, and this uneven melting would contribute to uneven deposition of drift. Blocks and masses of ice would be carried in the drift slumping down from the sides of the parts of the glacier remaining and these would partially contribute to the formation of depressions

*Conrey, G. W., Wayne County, p. 26, and map in pocket.

in the present topography. By the time these ice masses in the valleys had melted pretty well down, the melt water would be concentrated between the ice and the valley walls, particularly if the ice were in a valley which had an open drainage way to the south. Under such circumstances the material deposited after an open drainage way was established would be more or less assorted and stratified. Such stratified deposits, deposited between masses of ice and the valley walls, are very abundant in the larger open valleys in the form of kames and kame terraces.

These morainic deposits are located in the upper part of the valley of Paint Creek in southern Ripley and northern Monroe townships; in parts of the valley of Crab Run, not taken up with kame deposits; in the large preglacial Mohican valley south and west of Shreve and along the south side of the valley between Big Prairie and Loudonville; and to the southeast of Loudonville in southern sections 6 and 7, and western Section 8, in the western part of Washington Township. This last mentioned area of terminal moraine is the only one which is on the upland. Even here this upland is not as high as the main divide. The deposits in the preglacial valley between Big Prairie and Loudonville may be in part morainic but if so are masked by stratified material.

Deposits in the preglacial Mohican valley south and southwest of Shreve just south of the Wayne-Holmes county line and the extension to the southwest south of Big Prairie, in northwestern Ripley Township are a part of those mapped and described by Conrey farther to the north in Wayne County.* Leverett has also described this area of morainic topography.† The latter merely mentions the deposits, but Conrey gives a good description of them in Wayne County. Neither of these authors, however, distinguished between the morainic knolls between Big Prairie and Centerville which are made up chiefly of till, and the morainic-looking deposits nearer the center of the old valley which are made up mainly of stratified material. In the present paper the two types of deposits will be separated. Just south of the county line between Centerville and Big Prairie the topography is of a sag and swell character rather than of a knob and kettle type. It is not well marked off from the undulating upper slopes and hilltops to the south. The boundary between the ground moraine and the terminal moraine is therefore indefinite at this place and the boundary might be drawn somewhat higher or lower. In this region the terminal moraine exhibits very little in the way of undrained depressions of the real kettle hole type usually associated with a terminal moraine. The territory to the south mapped as ground moraine does not seem, however, to have quite so much of a sag and swell character. Near Centerville the moraine is weakly developed. A bit farther to the west nearer Big Prairie, in Section 28 and northeastern Section 29, the surface is more irregular and hummocky. This is especially evident near Big Prairie where the terminal moraine grades into deposits of kame-like character. A small extension of the moraine south of Odell Lake seems to be plastered

*Conrey, G. W., Wayne County: page 27 and map in pocket, 1921.
†Leverett, Frank, Mon. 41, p. 391.

against the hillside and up to the top of the ridge, but soon merges into ground moraine to the south.

In central Section 31 in northwestern Ripley Township the terminal moraine extends to an altitude of approximately 1,160 feet. All of Section 32 around Sprang School shows well developed knob and kettle topography. Some of these knobs are somewhat gravelly, but the material on the whole is mostly till. These knobs rise from 10 to 30 feet above the general level.

The upper or western portion of the valley of Paint Creek and its tributary valleys are partly filled with drift which is quite thick. The drift is known to be more than 130 feet thick in the valley bottom on the north side of Paint Creek in southeastern Section 15 in central southern Ripley Township, where a well on the farm of E. V. Gorrell is 130 feet deep and does not reach bedrock. The elevation of the well head is 1,020 feet. Mr. Gorrell states that a good flow of water was attained at this depth in a sand layer. Most of the drift here has an undulating surface and in places it approaches a knob and kettle topography. It is somewhat like the morainic surface in northwestern Ripley Township—not especially strongly developed. Prominent knolls of till are present in places, however. The streams tributary to Paint Creek seem to have established their courses from one depression to another. In the head waters the original topography is rather effectually masked. Probably preglacial Paint Creek occupied a good sized valley. Related to this morainic area small patches of gravel are present here and there, mostly near the streams and especially near Paint Creek. These are so small, however, that they were not mapped separately.

On the higher hills the drift is also fairly thick. Bedrock through here outcrops but rarely and not at all at the lower levels. The upland surfaces are flatter than those lower down, but are undulating in many places. The boundary between the ground and the terminal moraines is often not well marked. The ground moraine on the hilltops has a weaker expression than on the surfaces lower down. The boundary is therefore drawn where believed to best represent the change in surface character.

In the vicinity of Knox School in southeastern Washington Township in the valley of Crab Run, a small area has a terminal morainic expression. For about a half-mile on either side of the stream low drift knolls partly fill the valley and are plastered against its sides. The knolls in this area are feebly developed and the area as a whole can by no means be taken as typical of a terminal moraine. It is thought that the knolls are more definite than any undulations on the upland nearby and so the area is mapped as different from ground moraine.*

A small area of drift knolls is present in northern Washington Township between the lower part of Crab Run and Lake Fork. In this small area mainly in Section 35, till knolls are banked against the hillside, and across the low divide to the west. This area is somewhat

*Conrey, G. W., Wayne Co., pp. 34-36, and map, describes such areas in Wayne County as "minor morainic areas on the ground moraine."

related to areas of stratified drift nearby, but seems to be made up entirely of till.

One of the best developed areas of morainic topography is in sections 6 and 7, Washington Township and Section 12 of Hanover Township, Ashland County, just south of Loudonville. It is very close to the glacial boundary, in fact, it is the closest in the region. It differs from those previously described, being on the upland rather than in the valleys or along the valley sides. It attains an elevation of 1,160 feet in Section 12 of Hanover Township and 1,240 feet in northwestern Section 8, Washington Township. The maximum development, however, is not reached on this last higher hilltop. On the north, the area grades into a region of gravel kames and kettles, where the drift is thicker. The material is till, with only a small amount of gravel intermixed near the surface. At the county line and along the gravel road leading from Loudonville to Spellacy just west of the county line, the surface is very hummocky—real knob and kettle topography. Drift knolls 10 to 20 feet or more in height are scattered about and the depressions between are in many cases undrained kettle holes. Several of these kettle holes are partly filled with water, making small ponds and others show that small ponds existed in them until very recently. The largest of these is over 300 yards in diameter, and several have a diameter of more than 150 yards.

Stratified Deposits.

Stratified deposits of several types exist in the area. They are: valley trains, kames and kame terraces, eskers, and lake deposits. Valley trains will be mentioned briefly; eskers will be included in the treatment of kames and kame terraces, which will be treated in some detail because of their importance in this region; and the lake deposits will be located and described.

Valley Trains.

Valley trains, consisting of outwash deposited by melt water concentrated in streams flowing to the south, were deposited in the lower portion of the valley of Shrimplin Creek; in the lower part of Lake Fork valley; in the lower part of Griggs Valley; and in the valley of the Mohican River. This last extends far to the south and on down the Walhonding and Muskingum rivers. Along Shrimplin Creek and along the Mohican River these valley trains have been cut into by later stream erosion, and the outwash material remaining is in terrace remnants along the valley sides. The areas of valley train gravels in the region are shown on the map. The major one, that in the Mohican valley, of which that in the lower Lake Fork valley really is a part, extends far beyond Holmes County and is complicated by association with Illinoian glaciation in part of its course below Brinkhaven. A discussion of its features does not come within the scope of this paper. The one in the lower part of Shrimplin Creek valley more properly belongs with the deposits of Killbuck valley, which will be described elsewhere. That in the lower part of Griggs Valley will be taken up again in the description of the kames and kame terraces in that valley.

Kames and Kame Terraces.

Kames and kame terraces are the most unusual features connected with the glaciation of this region. Kame terraces have been described in the eastern United States,* but their only previous notice in Ohio, as far as the present writer is aware, is a brief mention of "esker terraces" by Wright,† located ". . . . in the River Styx in Medina County, between Seville and Wadsworth, and in the Mohecan River,‡ in Wayne County, in the vicinity of Wooster." As explained previously, it is believed that ice remained in the valleys after it disappeared from the hilltops. In a few cases, after the ice melted below the hilltops, temporary lakes were formed between the remaining ice mass and the hillside, and in these temporary lakes silt and gravel deposits were laid down. Some evidence of these ice-margin lakes is to be found, but apparently the ice-margined lake stage in any of the valleys was not very long lived. Flint§ has described ice-margin lake deposits of Connecticut in great detail. Most of the deposits in the valleys of this area, while bearing some similarity to Flint's ice-margin lake deposits, are not thought to have been deposited so much in lakes as in temporary channels between the ice remaining in the valley and the valley sides. Spillways⊙ such as are associated with the Connecticut ice-margin lake deposits, are not present in this area. The water was flowing to the south throughout the period of deposition of most of this material.

After the ice in the valley melted completely out, a hummocky terrace-like structure was left along one or both of the valley walls, with a depression—really an elongate kettle or series of kettles—in the central portion of the valley through which the present stream flows. The sides of these kame terraces show ice-contact slopes, where the gravel, formerly in contact with the ice mass, had slumped down upon melting of the ice. (See Fig. 3). These slopes have previously been regarded as stream cut, but while some stream cutting has taken place, most of the slopes are regarded by the writer as original ice-contact slopes. A method of testing the ice-contact character of the slopes bordering the streams is to compare them with those bordering the kettle hole lake basins, especially of Odell and Long (Bonnett) lakes. The slopes bordering the lakes must of necessity be original—no stream cutting can have occurred. By comparison therefore it is found that the two

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*Salisbury, R. D., Surface Geology—Report of progress, N. J. Geol. Survey, Ann. Rept., 1892, 93, p. 156, 1893.

Alden, W. C., The Physical Features of Central Massachusetts: Bull. 760, pp. 47–49, 1924.

Goldthwait, J. W., Geology of New Hampshire: Handbook No. 1, N. H. Acad. Science, pp. 35–36, 1925.

†Wright, G. F., Postglacial Erosion and Oxidation: Bull. Geol. Soc. America, Vol. 23, p. 285, 1912.

‡Killbuck Creek is probably intended here.

§Flint, R. F., Glacial Geology of Conn.: Conn. State Geol. and Nat. Hist. Survey, Bull. 47, 1930.

⊙Flint, R. F., Glacial Geol. of Conn., p. 99.

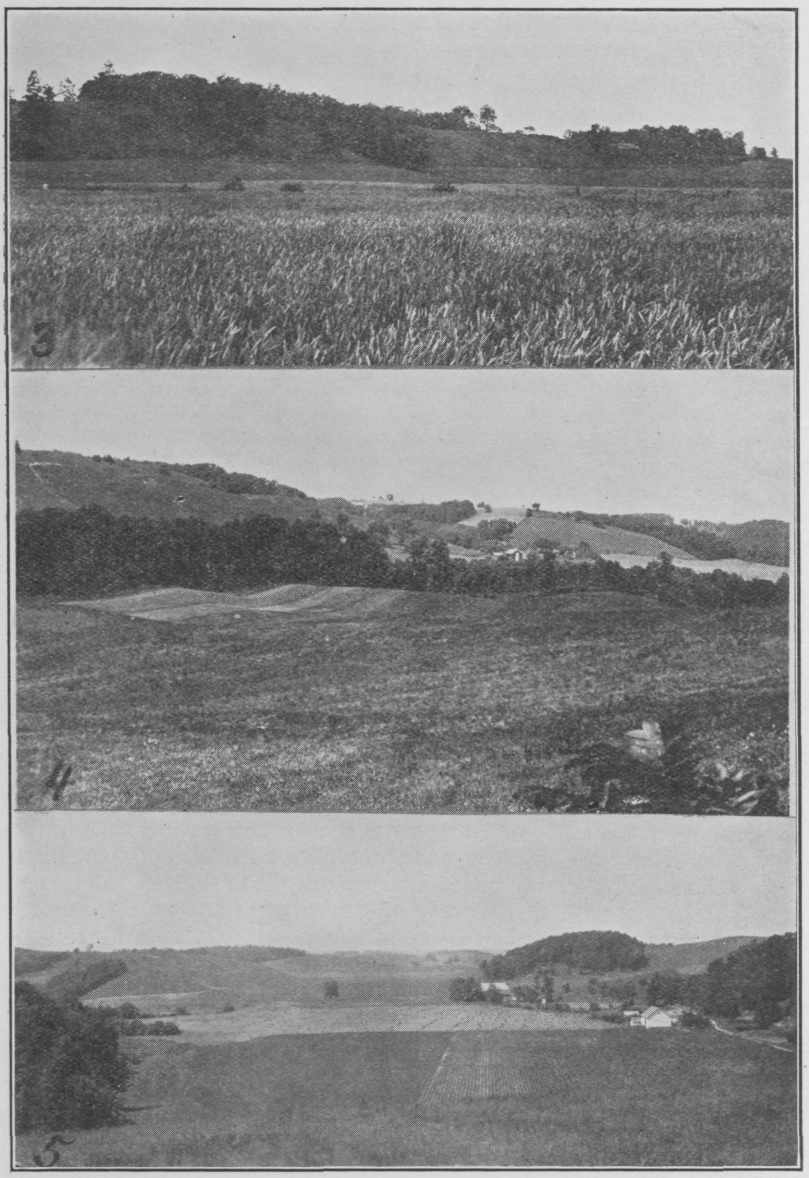

FIG. 3. Typical kame terrace showing ice-contact slopes. Stagnant ice rested in the foreground. West side of Killbuck valley, near Holmesville. (This is in Prairie Township, just east of the area under discussion.)

FIG. 4. Looking northwest across the valley of Lake Fork, southern Section 8, Washington Township. Kame deposits in foreground, till veneered rock-hills in background.

FIG. 5. Valley train in abandoned valley of Sigafoos Run (Griggs Valley). Looking north from glacial boundary, in Section 21, Knox Township. The till-covered hills on either side are remnants of the Harrisburg peneplain.

kinds of slopes are similar, and that the depressions through which the streams flow are merely drained elongate kettles.

Kames and kame terraces will be treated together. A kame in the present paper is a gravel knoll, deposited at or near an ice edge by running water. All gradations, from single isolated kames, to groups, and to terraces made by kames packed closely together, are found.

Valleys which carry these kame and kame terrace deposits are: the abandoned preglacial Mohican valley from Shreve to Loudonville; the valley of Lake Fork, both north and south of the great preglacial valley; the abandoned valley called Griggs Valley, which was formerly occupied by Sigafoos Run in preglacial times; the upper and especially the lower part of the valley of Crab Run; and a small valley northwest of Miley Crossroads in central western Ripley Township.

While these are the only kame and kame terrace deposits to be discussed in the present paper, it might be noted here that similar deposits are found in the deep valleys in the surrounding glaciated territory. Such deposits are particularly well developed in the valleys of Killbuck and Martins creeks in the central northern part of Holmes County.*

Lake Fork Valley—In the southern part of the valley of Lake Fork, that is, in section 8 and 17 of Washington Township, Leverett† observed:

> " . . . . in the midst of the valley, at considerably lower levels, there is a knob-and-basin topography. The basins cover several acres and the centers are depressed 10 to 15 feet or more below their rims. Their bottoms are peaty and marshy, and therefore presumably filled to some depth. They are surrounded by knolls of various sizes, form and trend, while near them at the border of the valley are level-topped gravel deposits standing 50 feet or more above the general level of the morainic tracts in the valley. Phenomena somewhat similar to these are displayed in several valleys in northwestern Pennsylvania just above the glacial boundary, and may be common in other parts of the glaciated district. Their cause is not well understood, but it is thought that they are probably due to the lingering of an ice mass in the central portion of the valley after a passage for the escape of water from beneath the ice had been opened along the borders of the valleys."

These knolls are regarded by the present writer as kames and not as morainic knolls. These kames fill the valley northward to about the place where the Loudonville-Millersburg road crosses the valley in northeastern Section 8. From the state road north to where Lake Fork leaves the preglacial Mohican valley, the kame-like knolls seem to be more confined to the valley sides and a more definite depression is present in the center of the valley through which Lake Fork flows. This depression is believed not to have been cut by the stream but to re-

*White, G. W., An Area of Glacier Stagnation in Ohio: Journal of Geology (in press), 1931.

†Leverett, Frank, Mon. 41 U. S. Geol. Survey, p. 391.

present the place where an ice block or blocks rested while deposits were being banked up between the remaining ice and the valley side. These deposits, while rudely terrace-like, do not have a flat top. (See Fig. 4.) The surface is very hummocky, being made up of kames and kettles. The inner borders of these terraces nearest the stream are ragged and represent ice-contact slopes against which the ice rested while the gravel was being deposited between the ice and the valley wall.

These gravel deposits in this part of Lake Fork valley seem to have been deposited by running water and not to have been deposited in lakes held in between the remaining ice and the valley wall. While these structures do not have flat tops such as would be deposited by a stream flowing south, it is believed that the absence of the flat top is because smaller ice blocks were numerous between the valley walls and the main mass of ice in the center of the valley. The gravel would be deposited between these masses of ice and perhaps entirely over them, so that originally this deposit may have had a flat top. When the many buried ice blocks melted, the surface became hummocky and kettled. If many blocks of ice of different sizes were buried in the terrace, it might show no traces of an original horizontal surface after the melting of all the buried blocks.

In northern Section 4 and southern Section 3 the deposit on the west side of the stream against the valley wall is gravel. Most of the deposit on the east side, however, is undulating till deposit which has been mapped as terminal moraine.

Griggs Valley—The abandoned valley of Sigafoos Run, which somewhat parallels the valley of Lake Fork before joining it in Section 4, Washington Township, is locally called "Griggs Valley." Gravelly kames, which are related to the kame gravels of the Lake Fork valley, are found from Griggs Valley School to the north end of the abandoned valley. Some of the gravel is quite coarse, containing cobbles up to one foot in diameter. In northeastern Section 9, in the north end of the valley, the material becomes more and more mixed with till. The deposit is quite terrace-like at the north end of the valley in central eastern and northeastern Section 9.

A considerable amount of melt water from the ice made its way to the south down this abandoned valley to Sigafoos Run which now flows out through the hills at the glacial boundary. A valley train, which is fairly level, heads at some kames about a quarter of a mile south of Griggs Valley School. (This is well illustrated in Figure 5.) It is made up of both sand and gravel, some of the latter being quite coarse. The elevation here is about 1,060 feet and decreases to 1,020 feet at the south end of the valley train. Some of the material of the southern part of this valley train may have been washed down from the vicinity of Nashville through the gorge-like valley of Sigafoos Run which carried melt water from an area to the west of Nashville. When the ice finally withdrew, the old outlet of Sigafoos Run to the north was choked. The new outlet through the hills to the west had carried sufficient melt water to cut the new channel so deep that it was retained.

Abandoned Valley, Sections 3 and 34, Washington Township—This abandoned valley, formerly tributary to the pre-glacial Mohican, is partly filled with kames, with an esker in the central part. The kames are 20 to 30 feet high and not packed tightly together. The evidence of many ice blocks and masses is quite clear in this short stretch. The fact, that ice in this valley was old and rotten and had no forward motion whatever, is shown by the presence in the center of this valley of the largest esker in Holmes County. This esker is a sharp ridge, 50 feet high in places and less than 20 in others, extending almost north and south for about a mile. The top is not level but quite ragged. The material is sand and fine gravel. The esker structure is probably much higher than it now appears because it is partially buried in later kame and wash deposits. Some drainage in addition to the subglacial drainage through the esker tube came down here beside the ice to join Lake Fork and then flow out to the south.

Crab Run Valley—The lower half and the headwaters of the valley of Crab Run have some gravel deposits separated by an area of weak terminal moraine already described. The deposits in the lower part of the valley will be taken up first.

To the south of the village of Lakeville are some of the best developed kame terraces of the whole area. A terrace made up of fine gravel is present for a little over a mile on either side of Crab Run south of Lakeville. The terraces are over a quarter of a mile wide and have a very hummocky surface with ice-contact slopes nearest the stream. Crab Run has done some lateral cutting but in the main the shallow inner valley is the low place or connected kettles left when the ice finally melted out of this valley. In places the terraces are 40 feet above the stream. Near Lakeville they have an elevation of about 980 feet. The tops of the terraces slope to the north, indicating that probably the drainage was north in the valley of Crab Run into Lake Fork and thence south, as is the present day drainage. The absence of gravel deposits in the southern part of the valley around Knox School precludes the possibility of any drainage to the south.

The terrace effect dies out and becomes rather an area of separate kames about a mile from Lakeville. Well developed kames continue from where the definite terrace seems to end up the valley into sections 11 and 12. The kames are higher and better developed near the valley wall, and are lower near the center of the valley. The material seems to be mainly fine sand and gravel. On the eastern side of the valley at the corners of sections 11, 12, 1, and 2 a north-south esker one-quarter mile long parallels the valley.

From the northern part of sections 11 and 12 south to the Loudonville-Nashville road is an area of low till knolls described previously. West and south of Nashville the head of the valley of Crab Run is partly filled by a few low gravelly kames which are also plastered against the hillsides. Above the area of gravelly kames the upper slopes are only slightly undulating and the deposit is till. One mile southwest of Nashville are low kame swells with some 20 to 40 foot kames to the west against the hillside. The material as seen in a small pit is mostly fine gravel. This area of kame and kettle topo-

graphy is quite subdued and not nearly as pronounced as that in the valleys here-to-fore described. These kame gravels could very well have been deposited off a retreating ice edge rather than around detached blocks, as was the case in many of the other valleys. The melt water from this area drained through a spillway to the southwest which connected the headwaters of Crab Run with the headwaters of Sigafoos Run. This took water from the vicinity of Nashville only and not from as far north as the kame deposits near Lakeville.

Central Western Ripley Township—A small area of gravel deposits is found in central western Ripley Township northwest of Miley Crossroads, practically confined to eastern Section 6. This is in the headwaters of a small stream flowing north to Odell Lake. The material is fine gravel and sand, mostly aggregated in kames and kame swells. The slopes of some of the kame swells are quite ragged, showing good ice-contact characteristics. A small esker 20 feet high and a quarter of a mile long, trending north-northeast is present in the center of the valley. The northern part of this small area of gravel deposits is surrounded by terminal moraine and on the south it is in contact with the upland and its ground moraine.

Preglacial Mohican Valley—The gravel deposits in the preglacial valley, where it crosses north and northwestern Washington Township, constitute the largest area and in some repects the most complex of any in the valleys of the region. Most of these deposits were laid down by running water, but some material was deposited in temporary lakes. Here also the largest continuous ice blocks were left as shown by present basins some of which now contain lakes.

This valley is filled to a considerable depth. At the south end of Odell Lake a well 200 feet deep did not penetrate to the bedrock. At Lovells Corners where the 3 C highway crosses from Holmes County into Ashland County, a well 110 feet deep was in gravel all the way. The valley filling is mainly aggregated in single and massed kames. The material is principally gravel, with some sand intermixed. A few of the knolls seem to contain some till and these may represent almost completely buried terminal morainic knobs. Level expanses are found here and there between some of the kames. This material, which was deposited in short-lived lakes, is more sandy and thinner bedded than that of the kames. In the northwestern corner of Washington Township in sections 29 and 30 is a well-marked flat area of sand and fine gravel, the elevation of which is approximately 1,000 feet. It is probably a wash plain deposited around ice blocks.

From Big Prairie to Lakeville the south side of the valley has gravel kames banked against the valley wall. The central part of the valley is occupied by the depression partially filled by Odell Lake. Just east of Big Prairie is a large elongate kame, trending east and west, made up of fairly coarse gravel. The gravel is 30 to 40 feet thick with apparently sand below. The gravel in the kames from Big Prairie to Lakeville, banked against the hillside, seems to be fine and sandy, with many sand layers. To the southeast the kame area grades into an undulating region of terminal moraine.

North of Lakeville, between that village and the county line, is a considerable area of kames and kettles. The surface is not as level as it appears from an examination of the topographic map. From Lake Fork west to Loudonville is an area of very well developed kames and kettles, some of the kettle holes containing tiny ponds. Other kettle holes, once containing ponds, as shown on the topographic map made in 1912, now are bogs. In general most of the smaller kettle holes are fairly well drained, because they are in gravel and the ground water soon percolates below the level of the bottom of the kettle holes. Most of these are from 10 to 30 feet deep. The larger basins in this region will be described under the heading of "lake basins."

In the vicinity of Loudonville and for a mile to the east, the valley is constricted and the area of kame deposits is narrower than that farther to the east. In northwestern Section 6, Washington Township, near Loudonville the gravel kames are especially well developed and many marked kettle holes, some of them over 100 yards across and 20 to 40 or more feet deep, are present between the kames. The gravel is medium to fine-grained. The bedding dips in different directions at various angles. The area just beyond the Loudonville city limits, crossed by the state road to Millersburg, is one of the most typical kame and kettle areas in the region under discussion.

Lake Deposits.

As the ice advanced into the region, the northward flowing valleys were the sites of temporary lakes, and drainage was established over the lowest divides to the south. It was in this way that the lower course of Lake Fork was established. The glacial outlets of all the other lakes were not cut down deeply enough to be permanent streams. As the ice retreated, the valleys, which slope to the north, again became the sites of lakes which emptied to the south through low places in the divides. These lakes were ephemeral, and surprisingly little evidence of their existence remains. The old beds of two of these lakes—flat areas of sand and silt—were observed. One, which covers an area about one mile long and one-half mile wide, is shown on the map in north central Monroe Township, a mile east of Phinney School. Lake deposits of this sort are also found at the low pass between the head waters of Crab Run and Sigafoos Run along the Knox-Washington township line one mile west of Nashville. Below the sandy surface, varved material probably exists, but no exposures are present.

Other lakes of an even more temporary character existed from place to place where water was trapped between the stagnant ice in the valleys and the valley walls. Such areas are not mapped separately because they are in intimate association with the kame gravels with which they are mapped.

Deposits of small temporary lakes are found around the bases of some of the kames in the preglacial Mohican valley. These show that the drainage from one low point to another was at places quite poor after the deposition of drift in this part of the region. On the north side of the 3 C highway in northern Section 32 of Washington

Township poorly exposed, undulating lacustrine layers were measured as follows:

	FT.	IN.
Gravel, very poorly sorted	4	0
Layers of sandy silt and darker silty clay, varying from 1/64 to 1/4 inch in thickness	5	6

A small deposit, the laminations of which may be seasonal, was observed along a lane in north central Section 6 of Washington Township, at an elevation of from 1,020 to 1,040 feet. This deposit is as high, or higher, than most of the kames to the west and north. The clay layers were from 1/8 to 3/4 of an inch thick and the sand layers from 1/64 to 1/4 of an inch thick. Each layer of clay had many thin sandy partings. This deposit is at the edge of an area of kame gravels where apparently a small lake was trapped between the stagnant ice to the north and the valley wall to the east. The material was measured here as:

	FT.	IN.
Gravel	8	0
Clay and sand, (varved?)	7	6

The peat and muck deposits, in some of the small kettle holes and in some of the larger ice block depressions such as those in the northwestern corner of Washington Township, are later than glacial times and do not come within the scope of the present paper. Some have already been described.*

LAKE BASINS AND PRESENT LAKES.

The lake basins in the region are all glacial in origin and are associated with stratified material in the preglacial Mohican valley. They are all kettle holes, some of great size. As the ice melted many large depressions were left in the stratified material in the valleys. The borders of these depressions show excellent ice-contact slopes where the gravel was built up against the ice blocks. Here there is no question about the slopes being trimmed by lateral planation of streams, because these depressions are occupied by lakes. By analogy, therefore, between the slopes of the lake basins and the slopes of the depressions now occupied by streams, the conclusion has been drawn as to the original ice-contact character of the slopes described previously. Those that were drained became part of a stream channel. Those which were not drained remained as lakes, some of which have been gradually filled, forming marshes.

The largest is Odell Lake, between Big Prairie and Loudonville. It is about one mile long and about one-quarter of a mile wide. It occupies a depression considerably longer but the same width as the lake. The lake is reported to be 15 feet or less in depth throughout. The Odell Lake depression was at one time occupied by a block of ice, which extended from Big Prairie almost to Lakeville.

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*Dachnowski, Alfred, Peat Deposits of Ohio: Geol. Survey of Ohio, Fourth Ser., Bull. 16, pp. 32-33, 77-78, 1912.

Long (Bonnett) Lake is in the northern part of Section 26, extending slightly over the county line into Ashland County. It is about three-eights of a mile long and a little less than a quarter of a mile wide. The basin which it occupies is about twice the length of the lake. This lake is considerably deeper than Odell Lake, having a uniform depth of 22 to 23 feet. The slopes of this basin show well developed ice-contact features.

Two large depressions and a smaller one, now connected by narrow channels and the whole drained by Plum Run, are found in the northwestern corner of Washington Township as shown on the map. The bottoms of these are at an elevation slightly deeper than 980 feet. The basins, partly filled with silt and organic material, have been artificially drained, and except for a few small patches lower than the usual level, are farmed. The compound basin of this old swamp is made up of smaller coalescing kettle holes rather than being one simple depression. The boundary slope is quite ragged, rising 20 to 30 feet above the former bog. An interesting feature is the presence, well out from the margins of the depression, of several small kames 20 to 30 feet high.